# Medical Imaging

# BMSC-GA.4426 ECE6813 BE6203

3 credits, Fall Semester 2020

**Dates, times and Faculty are indicative and will be confirmed at a later date.**

Course description:

This course introduces the physics, instrumentation, and signal processing methods used in X-ray (projection radiography), X-ray computed tomography, ultrasound imaging, nuclear medicine (SPECT/PET), and magnetic resonance imaging. The course builds on fundamental signal processing, basic electricity and magnetism, and multivariate calculus.

Goals and Objectives:

- Familiarity with the basic biomedical imaging modalities and their history
- Working knowledge of the basic physics, engineering and instrumentation principles of each modality
- Understanding of the typical applications for each modality
- Understanding of each modality strength and weaknesses
- Current research directions for each modality

Prerequisites:

Undergraduate level courses in multivariable calculus (MA-UY 2112 & MA-UY 2122 or MA-UY 2114 ), physics (PH-UY 2033 ), probability (MA-UY 3012 ), signals and systems (ECE-UY 3054). Students who do not have prior courses in signals and systems must take ECE-GY 6113 / BE-GY 6403 - Digital Signal Processing I as a prerequisite or must obtain instructor's approval; ECE-GY 6123 - Image and Video Processing is also recommended but not required.

Course Director EL6813/BE6203:

Prof. Yao Wang (NYU Tandon School of Engineering)
718-260-3469, yaowang@nyu.edu

Course Director GA4426:

Prof. Steven Baete (NYU School of Medicine),
212-263-4861, steven.baete@nyumc.org

Instructors:

Dr. Jonathan Mamou (NYU Tandon School of Engineering, Adjunct Professor)
917-225-0824, jonathan.mamou@nyu.edu, JMamou@RiversideResearch.org

Prof. Yu-Shin Ding (NYU School of Medicine)
212-263-6605, yu-shin.ding@nyumc.org

Format:

The course is organized as 12 150-minute lectures, two exams, and 1 lecture session used for a tour of medical imaging facilities (tentative). Students will be evaluated based upon course participation, homework and programming assignments, a midterm exam, a final exam.

Homework policy:

Homework will be assigned weekly and collected a week later. Homework solution will be provided the following week. Select homework problem will be graded and count towards the final grade. Exams will be primarily based on homework problems. There will also be several MATLAB assignments, and these will be collected and counted towards the final grade.

Grading policy:

Exam 1: 40%, Exam 2: 40%, Homework Assignments: 10%, Programming Assignments: 10%.

Lectures:

**For lectures 1-8**: Friday, 11:00 am-1:30 pm, Rogers Hall, Rm Jacobs Academic Bldg Rm 775B, Brooklyn Campus (NYU Tandon)

> Blended instruction applies: All lectures will be available virtually. Physical attendance will only be possible for lectures 1-8 at NYU Tandon and restricted to cohorts due to social distance requirements. Based on the current number of registered students, two cohorts will be formed. Cohort 1 will be able to attend in person Lectures 1, 3, 5, and 7, and Cohort 2 will be able to attend in person Lectures 2, 4, 6, and 8.

**For lectures 7-12**: Friday, 11:00 am-1:30 pm, virtual only.

Exams:

Both exams will be conducted virtually. Details to follow.

Textbooks:

J. L. Prince and J. M. Links, Medical imaging: signals and systems, 2/E, Prentice Hall, 2015. ISBN-10: 0132145189.

Outline:

Lecture #1 Introduction (September 4, 2020)

- Introduction to the course
- Overview of medical imaging modalities (history and basic principles)
- Review of signals and system basic concepts
- Image quality metrics

Lecture #2 Physics of radiography (September 11, 2020)

- Ionizing radiation
- Electromagnetic radiation
- Compton scattering

Lecture #3 Projection radiography (September 18, 2020)

- X-ray tubes
- Film/screen detectors
- conventional x-ray imaging equation

Lecture #4 X-Ray computed tomography (CT) part 1 (September 25, 2020)

- Instrumentation
- Image formation
- Radon transform

Lecture #5 X-Ray computed tomography (CT) part 2 (October 2, 2020)

- Back projection
- Filtered back projection
- Image quality

Lecture #6 Nuclear Medicine (October 9, 2020)

- The physics of nuclear medicine
- Positron Emission Tomography (PET)

**MIDTERM EXAM (October 16, 2020)**

Lecture #7 Physics of Ultrasound (October 23, 2020)

- Acoustic waves: properties of media
- Wave propagation: speed, reflection, attenuation
- Axial vs Lateral resolution
- Doppler effect

Lecture #8 Ultrasound Imaging (October 30, 2020)

- Ultrasound imaging principles
- Beam pattern formation and focusing
- Instrumentation (transducers, system components)

Lecture #9 Physics of Magnetic Resonance Imaging (November 6, 2020, virtual)

- Magnetization
- Precession and Larmor frequency
- RF excitation
- Relaxation

Lecture #10 Magnetic Resonance Imaging (November 13, 2020, virtual)

- Instrumentation
- Data acquisition
- Image reconstruction

Lecture #11 Advanced Magnetic Resonance Imaging (November 20, 2020, virtual)

- Image quality
- Diffusion MRI
- Functional MRI

Lecture #12 Clinical aspects of PET (December 4, 2020, virtual)

- Tracer Development and Validation
- Drug Pharmacokinetics & Pharmacodynamics
- Preclinical & Translational Research
- Clinical Applications

Tentative tour of the NYU Center for Biomedical Imaging (December 11, 2020)

- Tour of the RF Lab and explanation of RF coils components
- Tour of the MRI facilities (including a 7T whole body scanner)
- Practical session at the MRI console

The tour is very tentative and may be replaced by research seminars by prominent researchers in medical imaging.

**FINAL EXAM (December 18, 2020)**